Space Weather Technical Forecast

Issued on Monday, 02 January 2023 at 13:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of Moderate solar activity throughout. Active electron fluence expected through 02 and 03 January. Chance of G1/Minor Geomagnetic Storm intervals from later on 03 January onwards.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been marginally Low, with a number of C-class flares from AR3176 in the northwest quadrant and from AR3180 in the northeast quadrant. The peak flare was a C9.4, at 02/0621UTC from AR3176, which is the most magnetically complex region and which has slowly evolved through the period. There are five regions in total on the disc, with the other large regions, AR3177 and AR3179, having not produced any significant activity. AR3181 is a weak and newly developed alpha region. Three CMEs have been observed leaving the Sun in the last 24 hours, one large one from the eastern side, which has been modelled as heading away from Earth. One from the southeast and one to the southwest will be modelled when sufficient imagery becomes available. Following analysis of SDO imagery, the large flare from AR3176 appears to have given rise to a CME and will be analysed once this is discernible on SOHO imagery.

Solar Wind / Geomagnetic Activity: Solar wind as observed at L1 declined from around 550km/s to 480km/s in the waning influence of the high speed stream from coronal hole 59. Density was around average on a falling trend. Total magnetic field strength has been weak, with the north-south component persistently, but weakly, negative. Phi angle was predominantly positive (away from the Sun), with some brief negative orientations from around 02/0930UTC. Geomagnetic activity was mainly Quiet to Unsettled (Kp1-3), with an Active (Kp4) interval observed between 01/2100-2400 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at background levels. High energy electron flux (greater than 2MeV) has been at mainly high levels, with a peak of 2887 pfu at 01/1815 UTC. The 24-hour integrated electron fluence rose above the Active threshold. The observed fluence at 02/0000 UTC was 1.11e8 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Mainly Low solar activity is expected, but with an increased risk of Moderate activity. There is a slight chance of X-class flares due to the developing regions on the disc and from regions due to rotate onto the disc through the next four days.

Solar Wind / Geomagnetic Activity: A CME which left the Sun on 31 December is forecast to arrive at Earth on 03 January, but with low confidence. No further CMEs are currently forecast to affect the Earth. The high speed stream from coronal hole 59 is waning and is forecast to continue to wane through the remainder of 02 and 03 January. A possible combination of the high speed streams from coronal holes 60 and 61 are then forecast to connect on 04 January, with estimated speeds of 500km/s. Geomagnetic activity is forecast to start Quiet to Unsettled on 02 January, with an increasing chance of Active or G1/Minor Storm intervals through 03 and 04 January due to either CME or high speed stream effects. Residual geomagnetic storming is then possible for 05 January.

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Met Office Space Weather Technical Forecast

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES-16 is expected to remain at background levels throughout but with a chance of rising alongside any notable flares, giving a very slight chance of exceeding the S1/Minor Storm threshold. High energy electron flux (greater than 2MeV) observed by GOES-16 is likely to continue at mainly High levels, with a probable steady trend over the next couple of days. The trend is then lower confidence for 04 and 05 January, with uncertainties in the geomagnetic forecast. The associated 24 hour fluence is also expected to continue close to or above the Active threshold through 02 and 03 January with greater uncertainty for later in the period.

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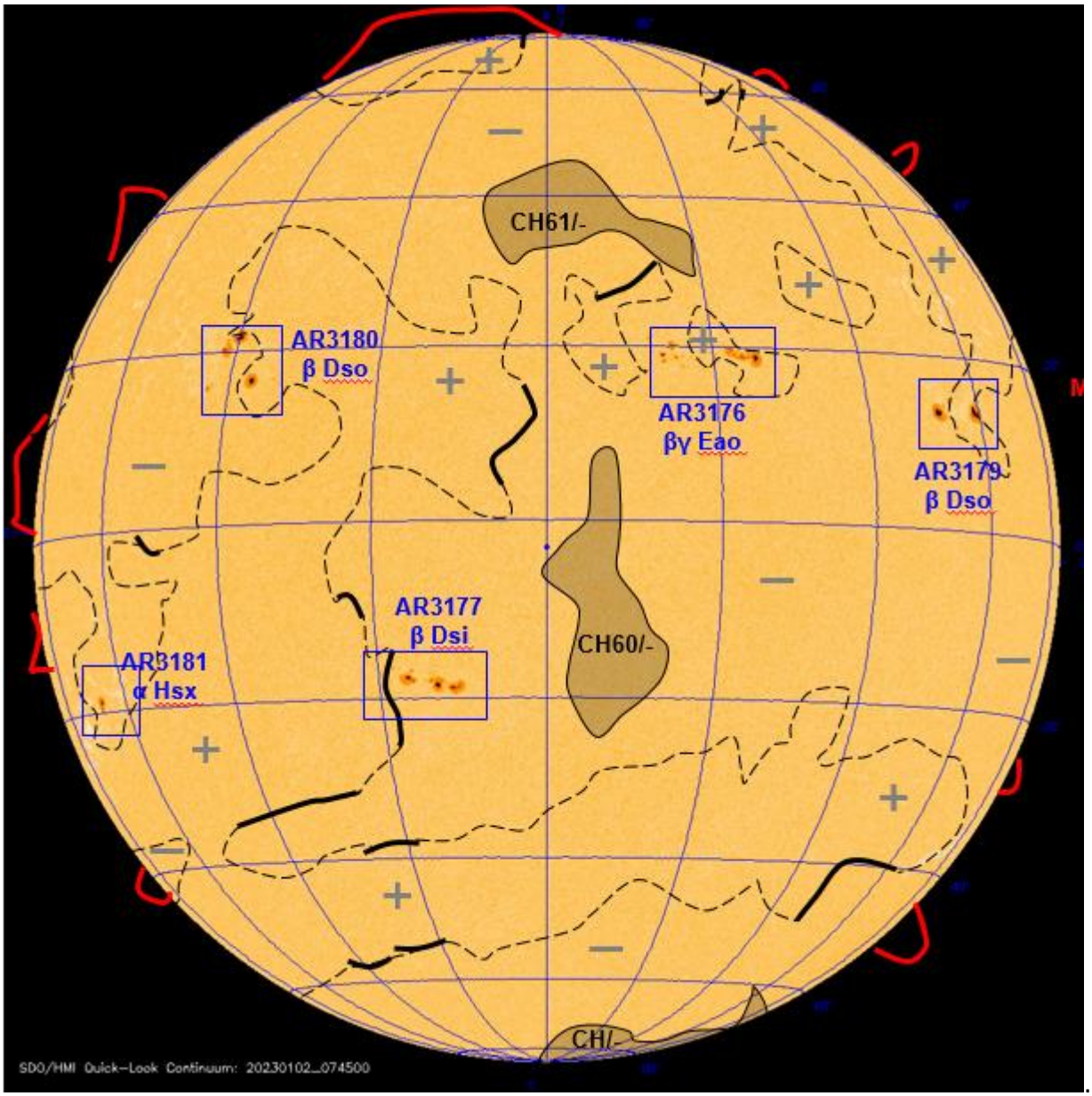
Figure 1. Solar Analysis Valid 02/0800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME which left the Sun on 30 December is forecast to arrive at Earth on 03 January, based on recent MOSWOC Enlil modelling. This forecast is subject to larger than usual uncertainty, due to limited imagery being available to calculate the initial parameters. No further earth-directed CMEs feature in the forecast, although two recent eruptions from the Sun will be modelled once sufficient imagery becomes available.

A high speed stream from coronal hole 59 is currently affecting the Earth, giving speeds in the region of 450-500km/s. There are recent signals to suggest that the Earth is moving out of the influence of this high speed stream, which is due to wane through 02 and 03 January. Coronal hole 61 is then due to connect with the Earth on 04 January, based on an estimated high speed stream speed of 500km/s. As the hole has evolved significantly over the last rotation, persistence is of little use, and STEREO A provides limited guidance due to a number of data gaps. The high speed stream from coronal hole 60 may also affect the Earth, but as this is far north relative to the Earth, any effects are likely to be masked by that of coronal hole 60.

Quiet to Unsettled geomagnetic activity is therefore expected on 02 January, with a risk of Active and a slight chance of G1/Minor Storm intervals on 03 January, due to the potential CME arrival. A CIR (co-rotating interaction region) followed by the high speed stream connection may then generate further Active or G1/Minor Storm intervals on 04 January. Depending on the timing and strength of the connection, residual storming is possible into 05 January.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	20	30	30
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
31/0141	Partial	M1 flare	AR3176	390km/s	03/1800 UTC	Low confidence

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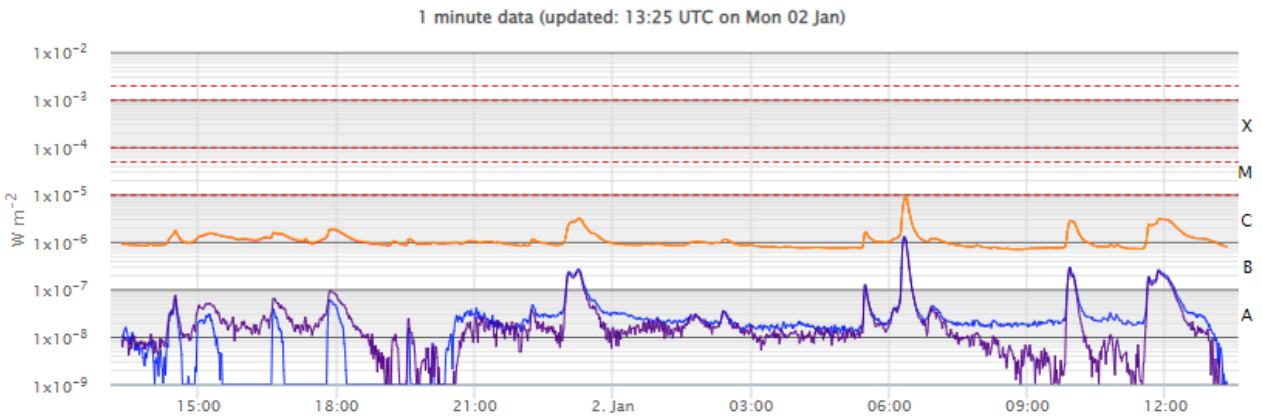
Radio Blackouts - X-Ray Flares:

Solar activity has been marginally Low over the last 24 hours, with much of the significant activity from AR3176 in the northwest and AR3180 in the northeast. The maximum flare in the period was a C9.4 at 02/0621 UTC from AR3176 as this region continues to slowly evolve. The remaining regions are relatively benign and inactive. There are a number of returning active regions due to rotate across the eastern limb through the next four days, with many of these producing generally C-class flare activity on the last rotation.

Solar activity is expected to be mainly Low through the forecast period, with a chance of M-class flaring, mainly from AR3176 and AR3180. There is also a slight chance of X-class flares.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 2: GOES 17 X-ray flux



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) measured by GOES-16 is at background levels. Any significant flares will bring a risk of proton flux rising at points during the period, with a slight chance of exceeding the S1/Minor Storm threshold. This risk increases slightly through the period, as AR3176 is transiting across the western hemisphere and is beginning to produce more active flares.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) is at high levels (1e3 pfu) as the radiation belts are under the influence of a relatively modest high speed stream. This increase is expected to level off through 02 January, as the high speed stream continues to wane. Under ambient conditions, the electron reduction is normally quite slow, but the possible effects of the CME arrival on 03 January, may lead to significant redistribution of the electron counts in the belts. Further impacts from the forecast coronal hole high speed stream connection on 04 and 05 January may then lead to a temporary reduction due to geomagnetic storming, although the forecast solar wind speed is considered lower than that required to significantly distort the radiation belts.

Electron fluence values are above the Active (1e8 integrated pfu) threshold and are expected to remain above this level through 02 and much of 03 January in the absence of significant modifying factors to the radiation belts. Uncertainty increases later in the period, but there is likely to be a balance between the level of any geomagnetic activity and electrons being restored into the belts by the solar wind.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	90	70	60	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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